

“Hoo-ah” or Ouch: Methodologies for Assessing Military Vehicle Occupant Injuries

11th Annual US Army Ground Vehicle Survivability Symposium

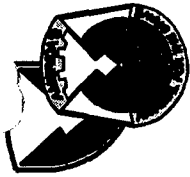
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Outline

Assessment Techniques

Live Animal

Human Surrogates

Human Volunteers

ATDs

Partial Body

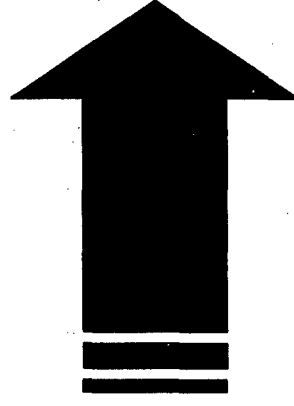
Simulations

Description

Advantages

Disadvantages

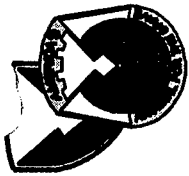
Methodology



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Full Body

Live Animal

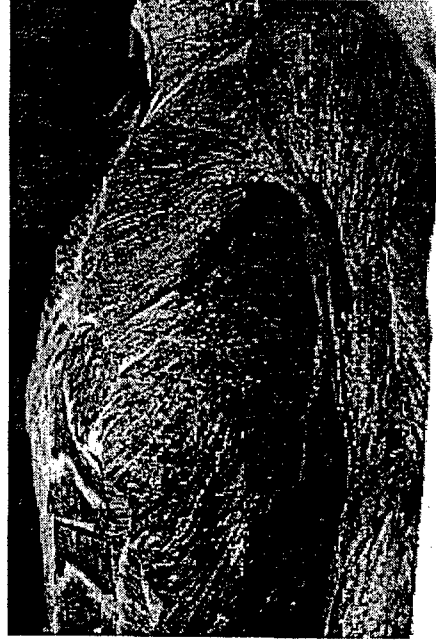
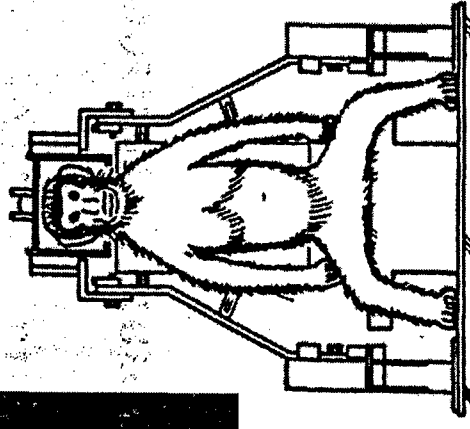
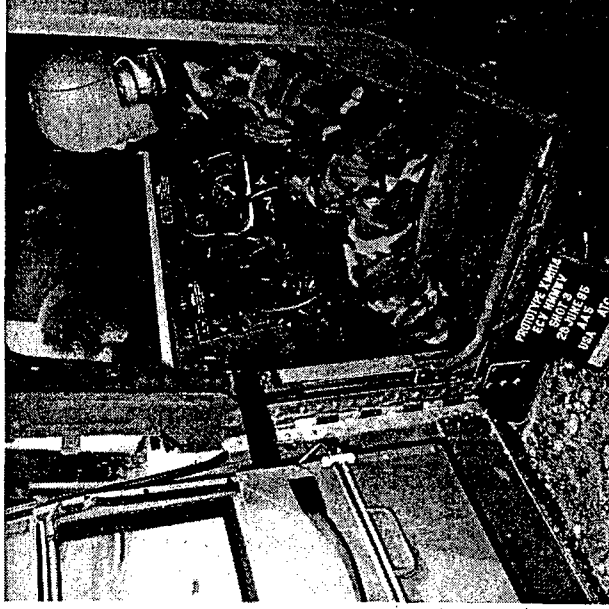
Human Surrogate

Human Volunteer

Anthropomorphic Test
Device (ATD)

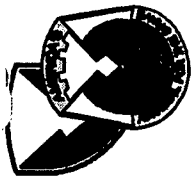
Simple

Bio-Fidelic



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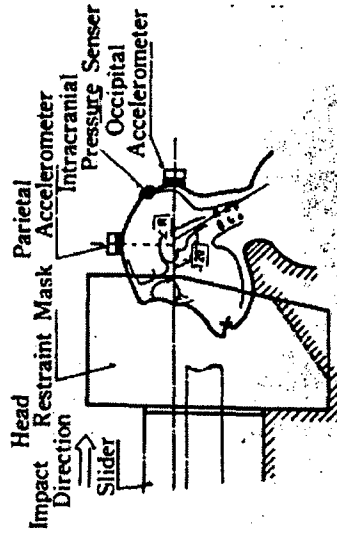
Live Animal Testing

Performed extensively in 1900's
through today by medical
community - product testing, and
tissue injury response

Extensive approval process to
obtain grants and comply with
federal / state regulation

Used by military for chemical /
biological / vulnerability studies -
goats in fragmentation / spill
testing

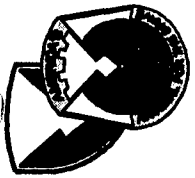
"Out of Favor" for political reasons,
alternative methods developed for
some research ...



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Live Animal Testing



Advantages

Swine soft tissue and organs (liver, kidney, heart) near in size and function of human

Monkey - similar physiological characteristics, greater intelligence

Live, bio-fidelic response

Disadvantages

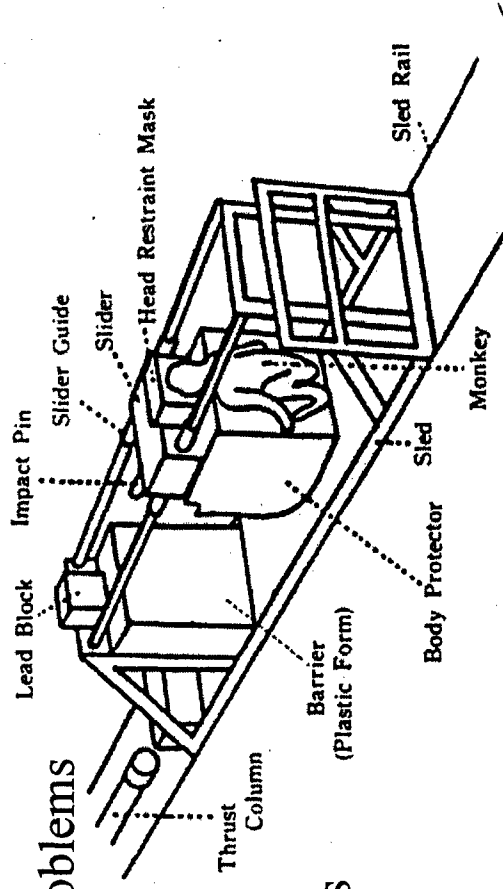
Sensitivity of cruelty to animals makes approval of experimentation difficult

Disease control, cleanup, potential toxicity problems

Non-ideal sensor locations on animals

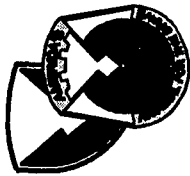
Reduced ability of test-to-failure

Correlation of bio-fidelity of results to humans



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Human Surrogate Testing



“Metabolically challenged” humans. Used extensively by medical schools for teaching.

Ability to closely simulate actual physiological responses to test objects.

Advantages

flexibility of test

“in vivo” instrumentation

repeatability of tests

test-to-failure

Disadvantages

unstable supply

gender/age bias

undetermined pre-existing conditions

lack of muscle tone

biohazard

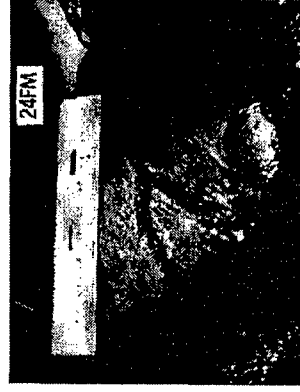
approval process & procedures



8D - ADVENTITIAL HEMORRHAGES
OF DESCENDING AORTA



8e - MULTIPLE RIB FRACTURES

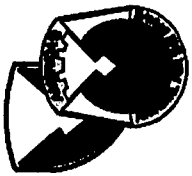


8h - LIVER LACERATION

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Human Volunteer Testing



Volunteers formed basis of aircraft crash tolerance limits. Testing has been conducted since WW1. Eiband, Stapp, Patrick, Mertz, et al pioneers in establishing tolerance levels using human volunteers.

Advantages

biofidelic response
gender/age specific studies
repeatability of tests
real-world testing (race car drivers)

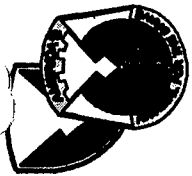
Disadvantages

inability to test to failure
lack of in-vivo instrumentation
scaling of data to injury levels
correlation of event to response



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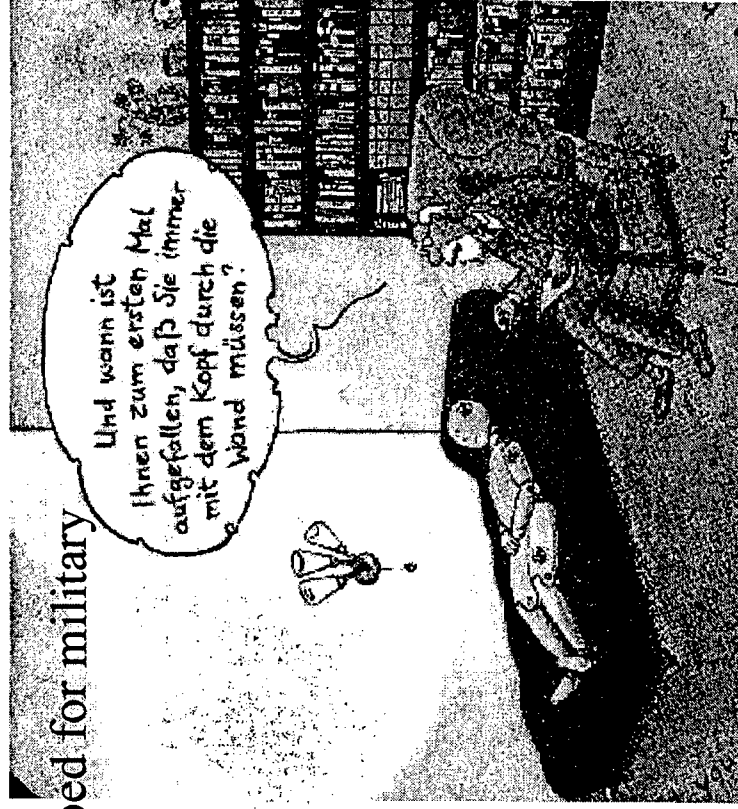
Anthropomorphic Test Device (ATD)



the real dummies in the world of testing...

Several types of ATD's have been developed for military vehicle occupant testing, among these...

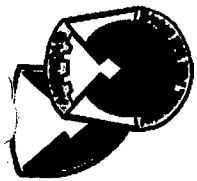
- wooden models
- "trashmen"
- "bottlemen"
- NHTSA Hybrid II and Hybrid III
- NHTSA SIDs



"Tell me when did you get this feeling that you had to go at everything head first?"

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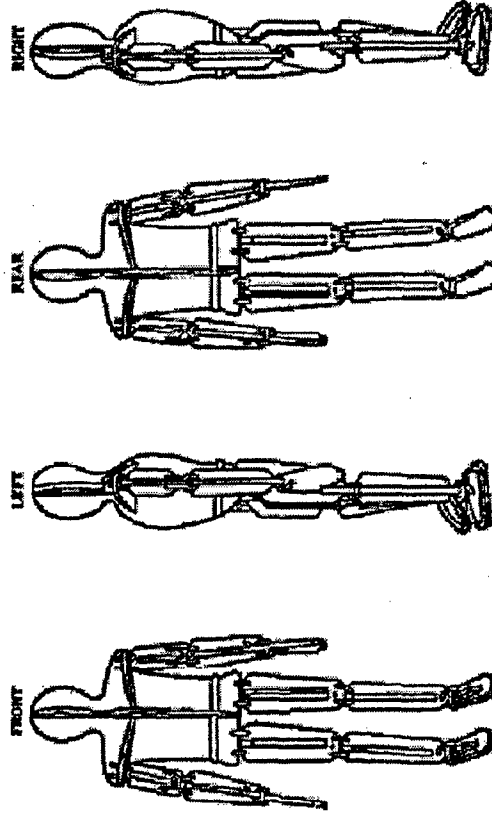
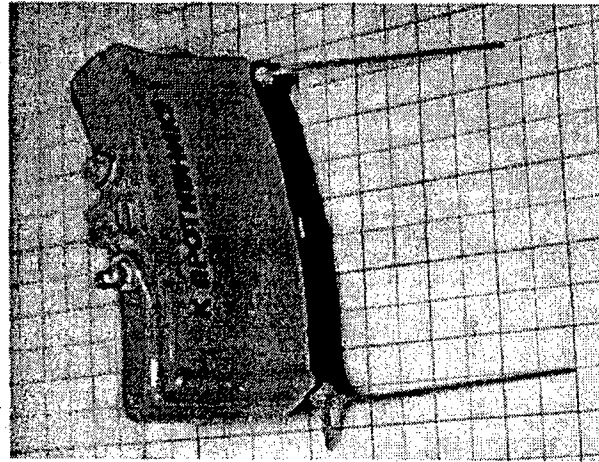
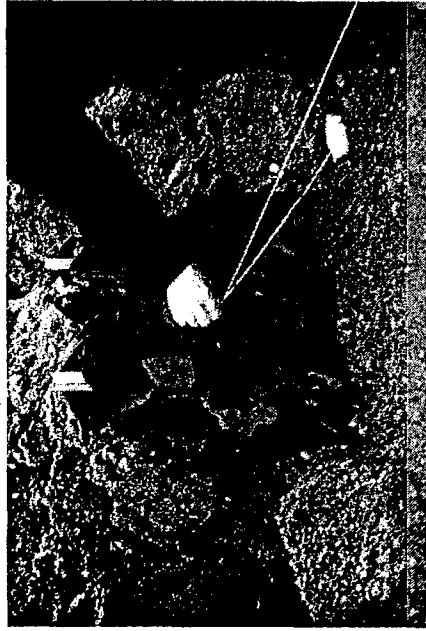
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Wood Models

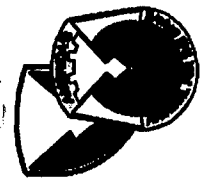


Utilized to determine evidence
of fragment penetrators from
both blast and anti-personnel
mines



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“Trashmen”



Non bio-fidelic
ATD intended to
simulate
occupant weight,
and obtain
acceleration data
(used during
development of
5 Ton-truck
crew protection
kit)

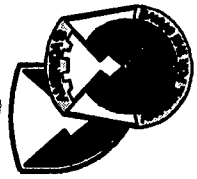


“Trashman” instrumented mannequin

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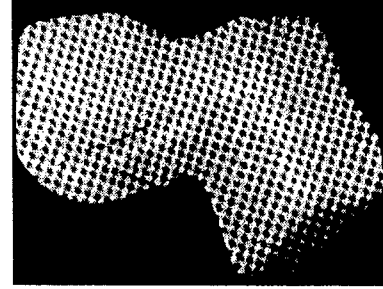
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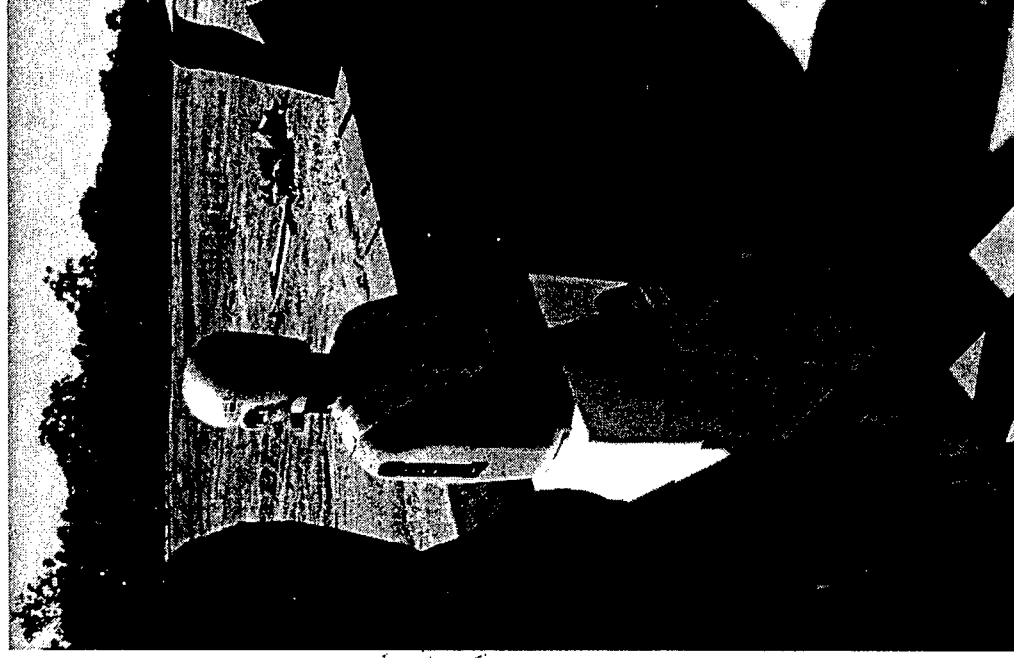
“Bottlemen”



Minimally bio-fidelic
ATD intended to simulate
occupant weight, and
obtain acceleration and
deflection data (used
during development of
South African series of
mine-protected vehicles)

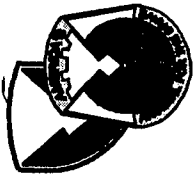


South African
“Bottleman”



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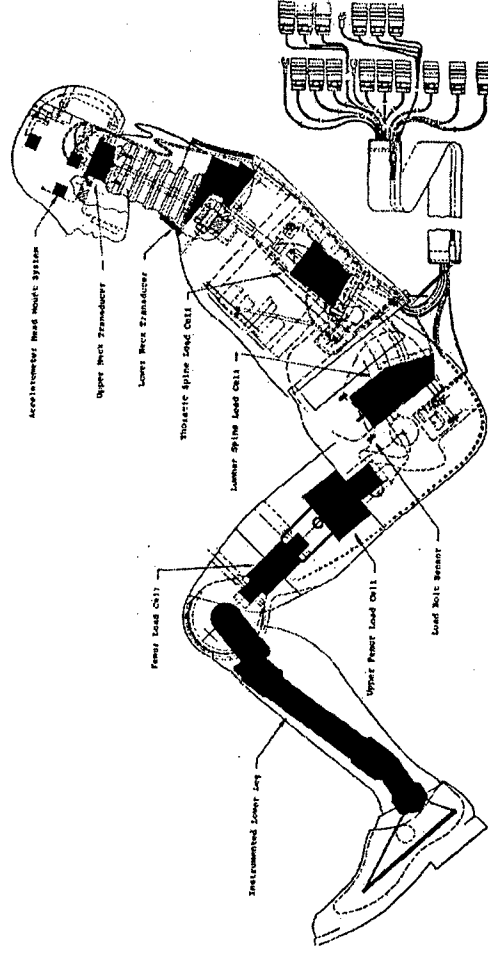


“Lifeman”



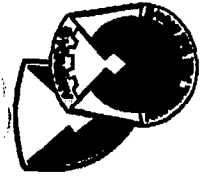
Current bio-fidelic ATD utilized by U.S. and European Automotive Industries for auto safety compliance testing as well as TECOM and Live Fire for crew tolerance testing. All evaluations utilize Hybrid III ATD's.

Load Cells
Used in the
Hybrid III 50th Percentile Male Dummy



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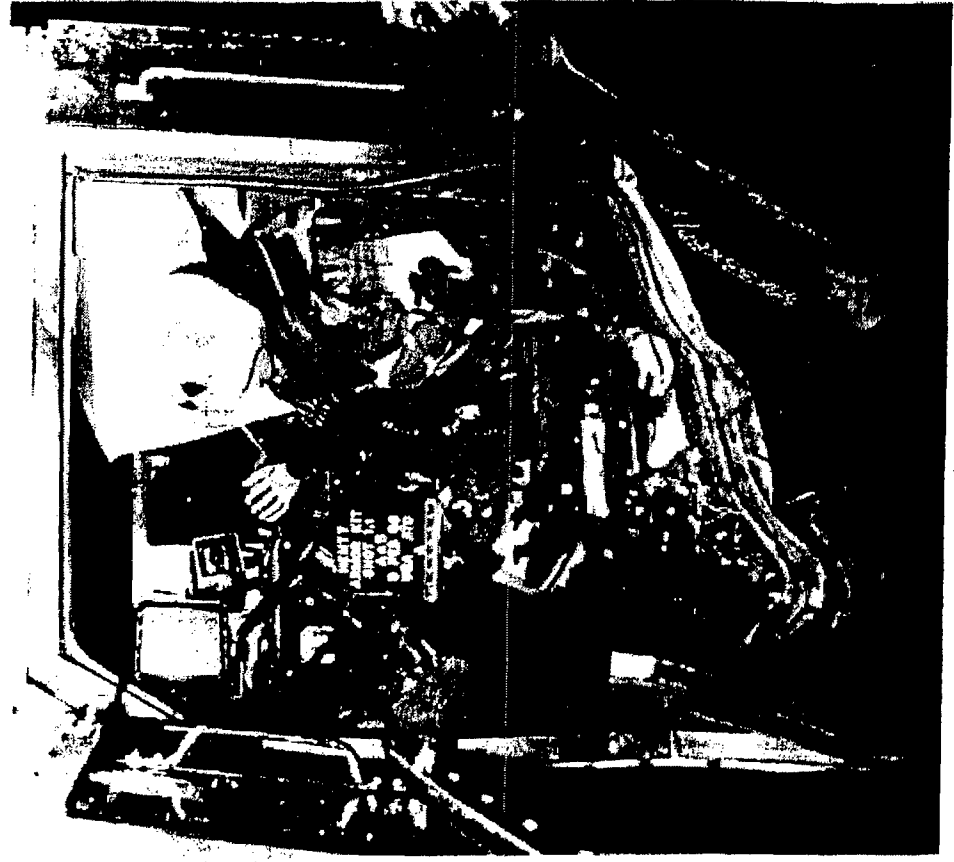
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“Lifeman”

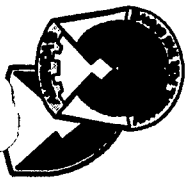


Hybrid III's utilized in mine-blast testing



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Partial Body Testing



- Specific-ATD designs to enhance biofidelity and increase ease of testing, minimizing apparatus design costs
- ATD as well as cadaveric test objects

Advantages

increased biofidelic response
repeatability of tests
test-to-failure

reduced test costs / overhead - fewer chambers
collection

Type of Partial Body Test Objects:

frangible leg - Australia

Thor leg - NHTSA

SID/BIOSID/EUROSID

clay for blunt impact trauma testing



Knee

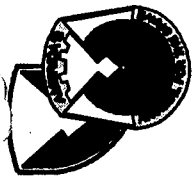
Ankle

Thor Lx

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Simulations



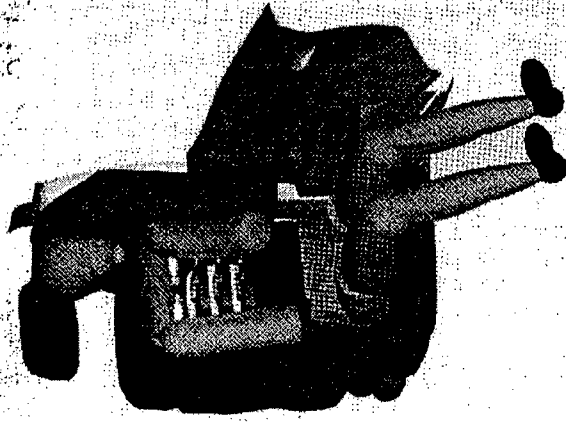
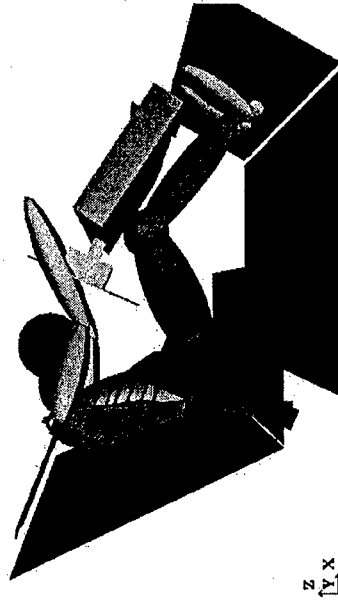
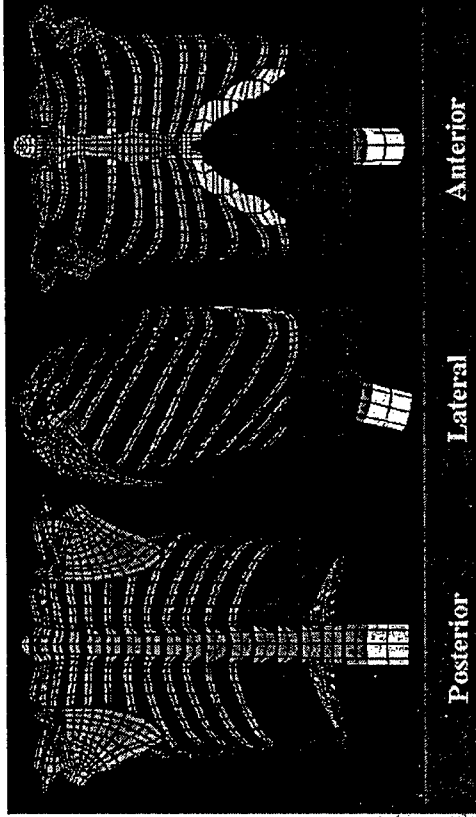
USAF/USAAAL - Articulated
Total Body (ATB) - occupant
kinematics

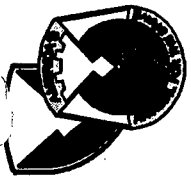
TNO - MADYMO - occupant
kinematics

DYNAMAN - occupant
kinematics

USAAAL - BLAST - injury
tolerance calculation

DIADem - Crash Base - injury
tolerance analysis





The Future



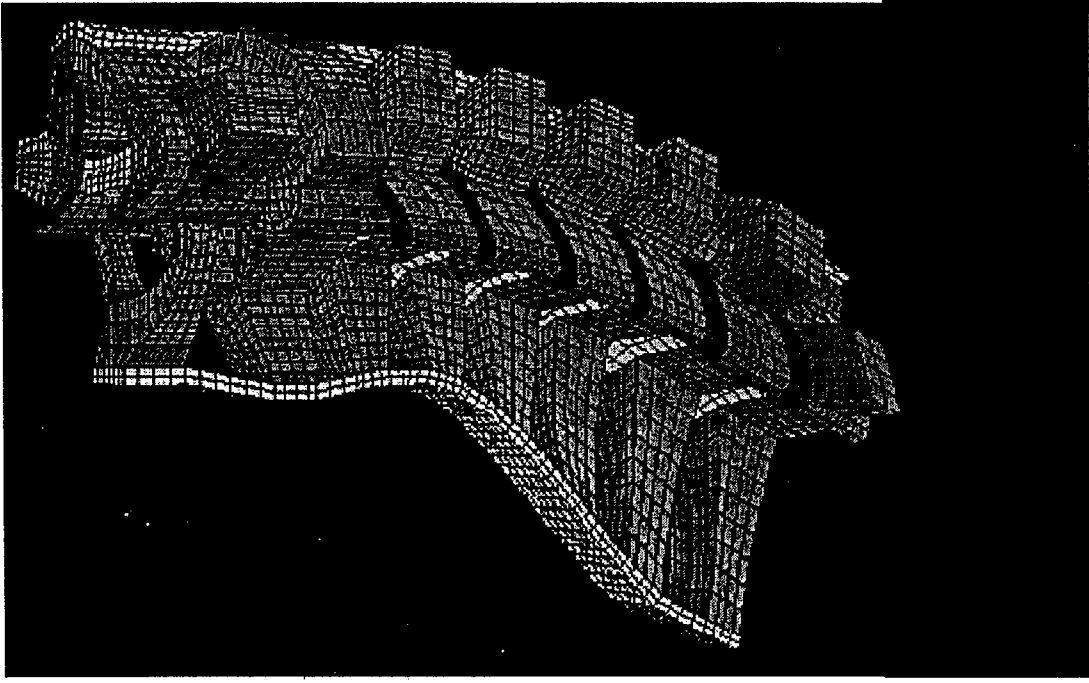
FEM Anatomic Neck Model

Increasing refinement and development of ATD's - harmonization

FEM's of spine, brain, organs, soft tissue to determine mechanical responses to injury

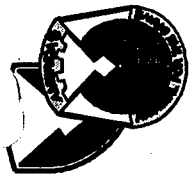
Continued use of human surrogates to validate FEM's

Coupling of FEM to vehicle dynamics and injury predictive models



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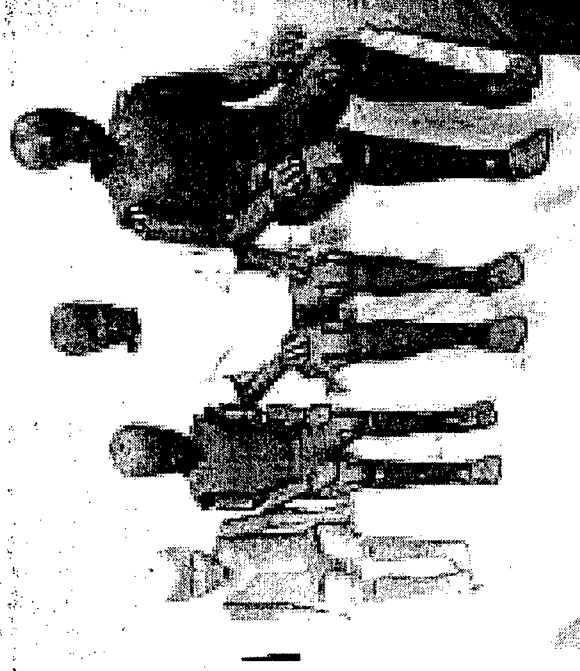
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OPSEC REVIEW CERTIFICATION
(AR 530-1, Operations Security)

I am aware that there is foreign intelligence interest in open source publications. I have sufficient technical expertise in the subject matter of this paper to make a determination that the net benefit of this public release outweighs any potential damage.

Reviewer: JAMES L. THOMPSON GM-15 Associate Dir, STA
Name Grade Title
James L. Thompson 17 Mar 00
Signature Date

Description of Information Reviewed:

Title: "Hoo-ah" or Ouch: Methodologies for Assessing Military Vehicle Occupant Injuries

Author/Originator(s): Gregory Wolfe

Publication/Presentation/Release Date: 29 MAR 00

Purpose of Release: 2000 Ground Vehicle Survivability Symposium

abstract, summary, or copy of the information reviewed is available for review.

Reviewer's Determination (check one)

- ☒ 1. Unclassified Unlimited.
- ☐ 2. Unclassified Limited, Dissemination Restrictions IAW _____
- ☐ 3. Classified. Cannot be released, and requires classification and control at the level of _____

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